38.4
C65
23

1
Odyssey Series

D. E. McAllister

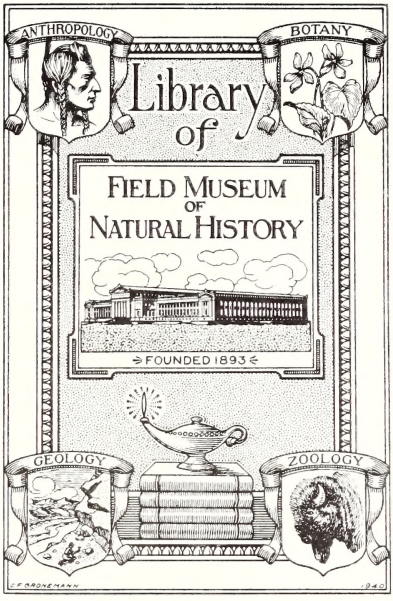
Old Fourlegs
A "Living Fossil"

National Museums of Canada
National Museum of Natural Sciences

Zoology
Division

SHOUT
SHARE
IT

THE FIELD MUSEUM LIBRARY
3 5711 00005 1434



Digitized by the Internet Archive
in 2014

https://archive.org/details/oldfourlegslivin00mcal

Old Fourlegs

635.4
.C65
M23

Old Fourlegs

A "Living Fossil"

An account of the coelacanth fish, *Latimeria chalumnae*

D. E. McAllister, Ph.D.
Curator, Ichthyology

Dr. McAllister has been Curator of Fishes at the National Museum of Natural Sciences since 1958. Born in Victoria, he graduated from the University of British Columbia and received his Ph.D. from that university in 1964. His research has taken him mainly to Newfoundland, Quebec, the Northwest Territories, British Columbia and Japan. Dr. McAllister has published over 50 scientific papers which have included studies on Arctic fishes, sculpins, smelts, fishes found in archaeological sites, light organs in fishes, and the classification of bony fishes.

Managing Editor: Norman J. Boudreau
Staff Editor: Jean Sattar

Designer: D. Schwob
Georges Beaupré, Graphiste

National Museums of Canada

National Museum of Natural Sciences

Zoology Division

Available by mail
from the
Marketing Services Division
National Museums of Canada
Ottawa K1A 0M8

Catalogue No. NM93-14/1

208020

6:20:78 Sep.

Contents

Capture of Living Coelacanths	a) The first specimen, 5
	b) Subsequent specimens, 7
Importance of the Coelacanth	a) Relationships, 7
	b) Fossil record, 9
	c) Significance, 9
Structure	a) General features, 10
	b) Head, 10
	c) Body, 12
Biology	a) Distribution, 17
	b) Food and growth, 17
	c) Reproduction, 17
Fishery, 18	
Acknowledgments, 18	
Bibliography, 20	

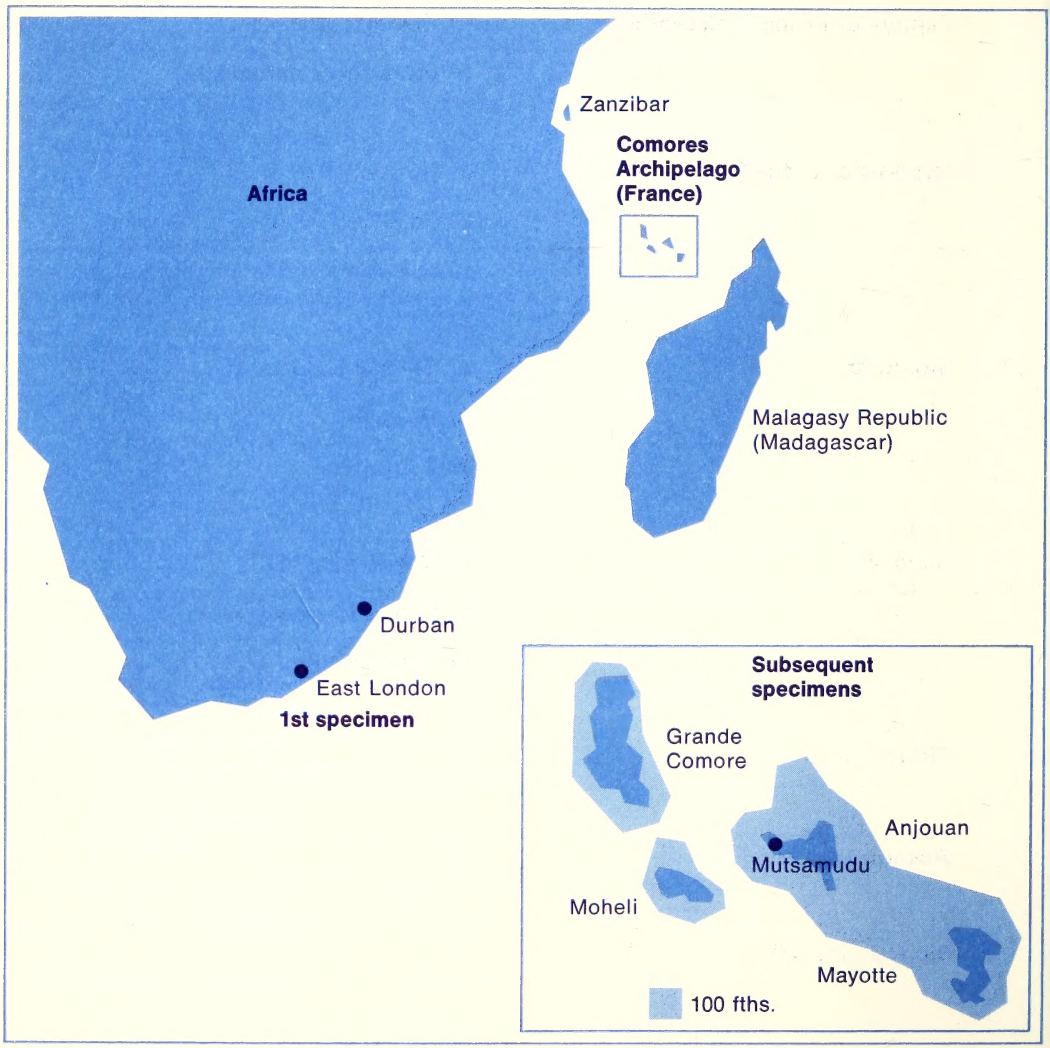


Plate 1. Sites of capture of the first *Latimeria* near East London, and subsequent specimens in the Comores Archipelago.

The first specimen

On December 22, 1938 a fishing boat, trawling at a depth of about 40 fathoms on a bank 3 miles off the mouth of the Chalumna River, which is 20 miles south-west of East London, South Africa, captured an unusual 5-ft long fish. It was so vigorous that even after being hauled up from a depth of 240 ft amongst a catch of sharks it snapped viciously at the hand of the captain, and it showed signs of life on the hot deck for almost 3 hours afterward. This remarkable vigour, and the creature's steel-blue colour, limb-like fins, and strange aspect so struck the captain that he saved the specimen. But he little realized that here was a fish known to the world of science only from fossils. On the boat's return to port, the fishing firm phoned Miss M. Courtenay-Latimer, curator of the East London Museum, who had secured the firm's assistance in obtaining specimens of unusual fishes.

Although not an ichthyologist she recognized that the fish was unusual. She had its weight taken; it was 127 pounds. Then, despite its size, the fact that it was beginning to decompose, and that the Christmas holiday was imminent, she took the fish to the museum in a taxi. She had to persuade the reluctant taxi driver to permit the fish in his vehicle. At the museum she measured it, then took it to a taxidermist for mounting, having no container in which to preserve it whole.

The next day Miss Courtenay-Latimer wrote Dr. J. L. B. Smith, an active South African ichthyologist, describing the fish and attaching a sketch of it. The letter arrived late, due to the holidays. Meanwhile, Miss Courtenay-Latimer, not realizing the delay and not having received a reply, concluded that Dr. Smith did not consider the fish of great importance and disposed of the internal organs. When Dr. Smith had read her letter, he stared puzzled at the sketch. He knew of no similar fish from South African waters. Then in a flash he remembered the Crossopterygii, an ancient group of fossil fishes commonly known as lobefins. But it was not until a frustrating month had gone by that Dr. Smith, assailed by doubts, was finally able to visit the East London Museum and examine the specimen. His intuition had been right; it was a coelacanth, one of the ancient subclass Crossopterygii.

Soon the news reached the local press and spread around the world. Smith was deluged with enquiries, letters, and wires. Newsmen and scientists were eager for information. Smith then succinctly described the fish (Smith 1939) and gave it a new scientific name, *Latimeria chalumnae* Smith. The generic name *Latimeria* honoured Miss Courtenay-Latimer, who was responsible for saving the specimen, and the species name, *chalumnae*, referred to the Chalumna River near which the fish was caught. The trawlermen, followed by the press, named it "old fourlegs."

In time the furor in the press quietened and Dr. Smith got on with the job of a detailed anatomical study (Smith 1940). This monograph confirmed with startling accord many of the views of palaeontologists who had studied only fossils and also added much new knowledge of its structure. Unfortunately, due to the mode of preservation of the specimen, little could be reported of its internal anatomy.

In hopes of securing additional specimens Smith launched a campaign.

Leaflets bearing a photograph and description of the fish and offering a £100 reward for a coelacanth were printed in Portuguese, English, and French and were distributed along the coast and islands of East Africa and Madagascar. But it was not until 1952 that the campaign showed results. On December 24 of that year Smith received a wire from a schooner captain, Captain Hunt, who had secured a 5-ft coelacanth in the French-governed Comores Archipelago, a group of small islands situated between Africa and the north end of Madagascar. It was vital to ensure the proper preservation of this specimen, and therefore needful for Smith to go to the Comores. But no regular air line service was available; finally Smith, after trying all other channels, phoned the South African Prime Minister, Dr. D. F. Malan. Although aware of the risk that the specimen might be misidentified, Malan nevertheless appreciated the significance of the find and authorized Smith's use of a military plane for the 2,000-mile trip to the Comores to secure the find. The fish was a coelacanth. A native had carried the 90-lb specimen for 25 miles over mountains from the other side of the island to Hunt's vessel. It was reported that in the Comores this fish was previously known, although seldom caught by the natives. In fact it was popularly remarked that people had been using its rough scales to prepare the inner tubes of their bicycles for patching. The natives call the fish *gombessa djomole.*

The second coelacanth was flown back to South Africa. It was different from the first specimen in that it lacked the first dorsal fin and the central lobe of the tail fin. Because of these differences Smith named it a new genus and a new species, the genus *Malania* after Prime Minister Malan, the species *anjouanae* for the Comoran island of Anjouan near which it was caught. It now appears that this was an aberrant specimen and did not represent a new form (Millot 1955*a*). The full story about the finding of the first coelacanths may be read in J. L. B. Smith's book, *Old Fourlegs* (see Bibliography for various editions).

Plate 2. The 52-inch, 92-pound specimen of *Latimeria chalumnae* preserved in the ichthyological collection, National Museum of Natural Sciences, Ottawa.

Subsequent specimens

The home of the coelacanth had been found: the Comores Archipelago. The French government began efforts to secure additional specimens. The next one was caught in September 1953; by mid-1955 seven had been caught, and by mid-1969 forty-four specimens had been collected in the Comores. Specimens have been taken only near the islands of Grande Comore and Anjouan. A research team was set up under the leadership of Dr. Jacques Millot and began detailed studies on preserved and living material. While Drs. J. Millot and J. Anthony have authored most of the anatomical studies, other specialists have been called in to study certain tissues, organs, or aspects of physiology. Short preliminary reports on the studies are published first, keeping scientists up to date. These are followed by publication of large, well-written, elegantly printed and beautifully illustrated monographs, two of which have now appeared (Millot and Anthony 1958; Millot and Anthony 1965).

Relationships

There are four major groups or classes of living fishes. These are the **Amphioxi**, comprising the lancelets; the **Cyclostomata**, which includes the lampreys and hagfishes; the **Elasmobranchii**, which includes the sharks, rays, and chimaeras; and the **Teleostomi** or bony fishes, which includes most of the ordinary living fishes. The Teleostomi are divided into three major subclasses: the Crossopterygii or lobefins, the Dipneusti or lungfishes, and the Actinopterygii or rayfins, which includes most of the living fishes from the sturgeons, trouts, and perches to the angler fishes.

It is the Subclass Crossopterygii of the Class Teleostomi to which the coelacanth belongs. There are two subdivisions of the Crossopterygii, the Superorder Osteolepides, known as the rhipidistians, and the Superorder Coelacanthi, known as the coelacanths. The rhipidistians are the fishes that gave rise to the Amphibia—the frogs, salamanders, and caecilians—and thus eventually to the higher vertebrates, including man. The rhipidistians are known only from fossils. The coelacanths, however, have one known living representative, *Latimeria chalumnae.*

The position of *Latimeria chalumnae* amongst living vertebrates may be outlined as follows:

Pisciform Vertebrates

Class Amphioxi – lancelets
Class Cyclostomata – lampreys, etc.
Class Elasmobranchii – sharks, etc.
Class Teleostomi – bony fishes

Subclass Crossopterygii – lobefins

Superorder Osteolopides – rhipidistians[1]

Superorder Coelacanthi – coelacanths

Order Coelacanthiformes
Family Latimeriidae

Latimeria chalumnae: – "old fourlegs," the coelacanth

Subclass Dipneusti – lungfishes
Subclass Actinopterygii – rayfins

Tetrapod Vertebrates

Class Amphibia – frogs, etc.
Class Reptilia – lizards, etc.
Class Aves – birds
Class Mammalia – mammals

[1] Known only from fossils.

Fossil record

The fossil record of the Crossopterygii is a long one. It extends from the Lower Devonian (400 million years ago) to the Upper Cretaceous (65 million years ago). Compared with the coelacanths, Prof. Millot says, dinosaurs lived only yesterday; coelacanths are nearly 200 million years more ancient than the first dinosaurs. Fossil coelacanths are known from all continents (except Antarctica) and from the island of Madagascar.

The rhipidistians appeared first in the fossil record. After having given rise to the amphibians they disappeared relatively early—in the Lower Permian. The coelacanths, which appeared slightly later than the rhipidistians and evolved from them, were long lived and are known as fossils until the Upper Cretaceous. During their first 30 million years they evolved rapidly; following this they changed little, so that *Latimeria* is not greatly different from coelacanths of the Mississippian (Schaeffer 1952*b*). Early coelacanths were mainly inhabitants of fresh water; later, marine forms were frequent.

At the end of the Cretaceous period coelacanths disappeared from the fossil record. From rocks of that time to those of the present, representing a period of about 65 million years, no coelacanths are known. It was this, coupled with the absence of living forms, which gave rise to the belief that coelacanths were extinct. Despite this blank in the fossil record we now know that they must have been present during this period.

Significance

Latimeria chalumnae is very important to scientists because it is the closest living relative of forms that gave rise to the higher vertebrates. It is also the only living member of the lobefins or Subclass Crossopterygii. From a study of *Latimeria* scientists may understand much more about the poorly preserved soft anatomy hitherto little known in fossil lobefins. As J. L. B. Smith has said, coelacanths are incomparable "machines for reading time backwards." It has also provided palaeontologists with a valuable check on palaeontological interpretation. The interpretation of fossil coelacanths has proved to be surprisingly accurate, despite the meagre remains on which they are often based. Lastly, it provides a warning to scientists never to be too dogmatic.

It should be remarked that *Latimeria* is *not* a missing link; it is not directly ancestral to terrestrial vertebrates. Rather it is a fairly close relative of those ancestral forms, the rhipidistians. As such it might be called a "side branch" or a "side link" of the ancestral form.

General features

At first glance, a coelacanth looks like a rather robust mullet. But only slightly closer inspection shows features distinguishing it from mullets and all other living fishes. These and other features are described below in a general account of some of the more interesting anatomical characteristics.

Latimeria, when alive, is a sombre grey-blue, with light, almost white spots placed irregularly along the sides of the head and body. The blue approaches that of a steel watch spring. Some specimens show a violet blue iridescence on a brown background. The eyes of a living fish were reported to be luminescent. But perhaps rather they are highly reflective, giving the illusion of light production, as do the eyes of many species that habitually live under low light intensities.

The length of captured specimens varies from 40 to 70 in., the weight from 30 to 176 lbs.

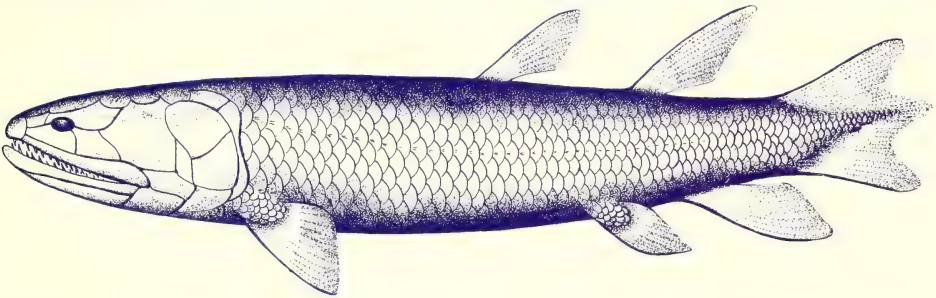
Head

The head, eyes, and jaws are of moderate size. On the lower side of the head between the jaws are a pair of large bony plates called gulars (*see* Plate 5). These are found only in the more primitive bony fishes. Sharp conical teeth adorn not only the jaws, palate, and tongue, but also the inner side of the gill arches, equipping the fish for a predatory existence. A maxillary, a bone of the upper jaw found in most bony fishes, is lacking. On each side of the snout is a pair of nostrils. The tube-like anterior nostrils are located on the upper lip, a feature not unusual in bottom fishes. In *Latimeria*, unlike some rhipidistians, internal nares do not connect the nostrils with the mouth.

Also in the snout is a rostral organ, an organ whose function, though probably sensory, is as yet unknown. The rostral organ consists of a central cavity opening to the surface through three mucus-filled tubes on each side of the snout. The organ is richly innervated by branches of the superficial ophthalmic nerve. This organ may be comparable although not necessarily homologous, it is here suggested, to the ampullae of Lorenzini, jelly-filled canals in the snouts of sharks. The ampullae of Lorenzini have been variously suggested to sense electric currents, temperature or pressure. Further research is needed to decipher the function of the rostral organ, but because of structural similarities to electro-receptors in other fishes the author would like to suggest that its function is to detect electrical currents of biological origin.

There are five gill arches, but the last is considerably reduced and does not bear a gill. A well-developed false-gill or pseudobranch is present under the gill cover. A remnant of a spiracle is present in the form of a blind internal pocket. But it does not open to the surface as it does in the elasmobranchs, sturgeons, paddlefishes, and bichirs.

As in the fossil rhipidistians, but unlike other fishes, the cranium is divided into two units. The front (ethmosphenoid) and back (otico-occipital) parts meet behind the eye and are joined by fibrous tissue, ligaments, and muscles. These permit only limited movement, through an angle of about 15 degrees (Thompson 1966). This joint has been suggested to function as a shock absorber, cushioning the brain from the snap of the powerful jaws, although this seems unlikely. Raising the front part of the



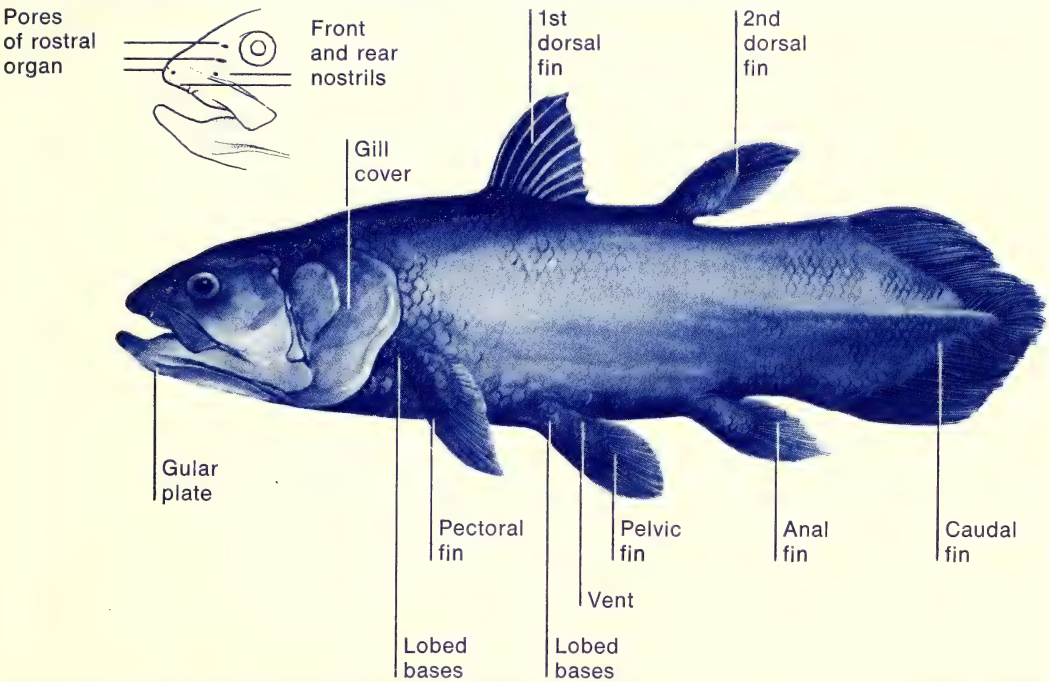


Plate 3. The Upper Devonian fossil rhipidistian *Eusthenopteron foordi* from the Gaspé Peninsula. The lobe-like pectoral and pelvic fin bases and tri-lobed tail fin of this ancient fossil resemble those of *Latimeria chalumnae.*

Plate 4. External anatomy of *Latimeria chalumnae.*

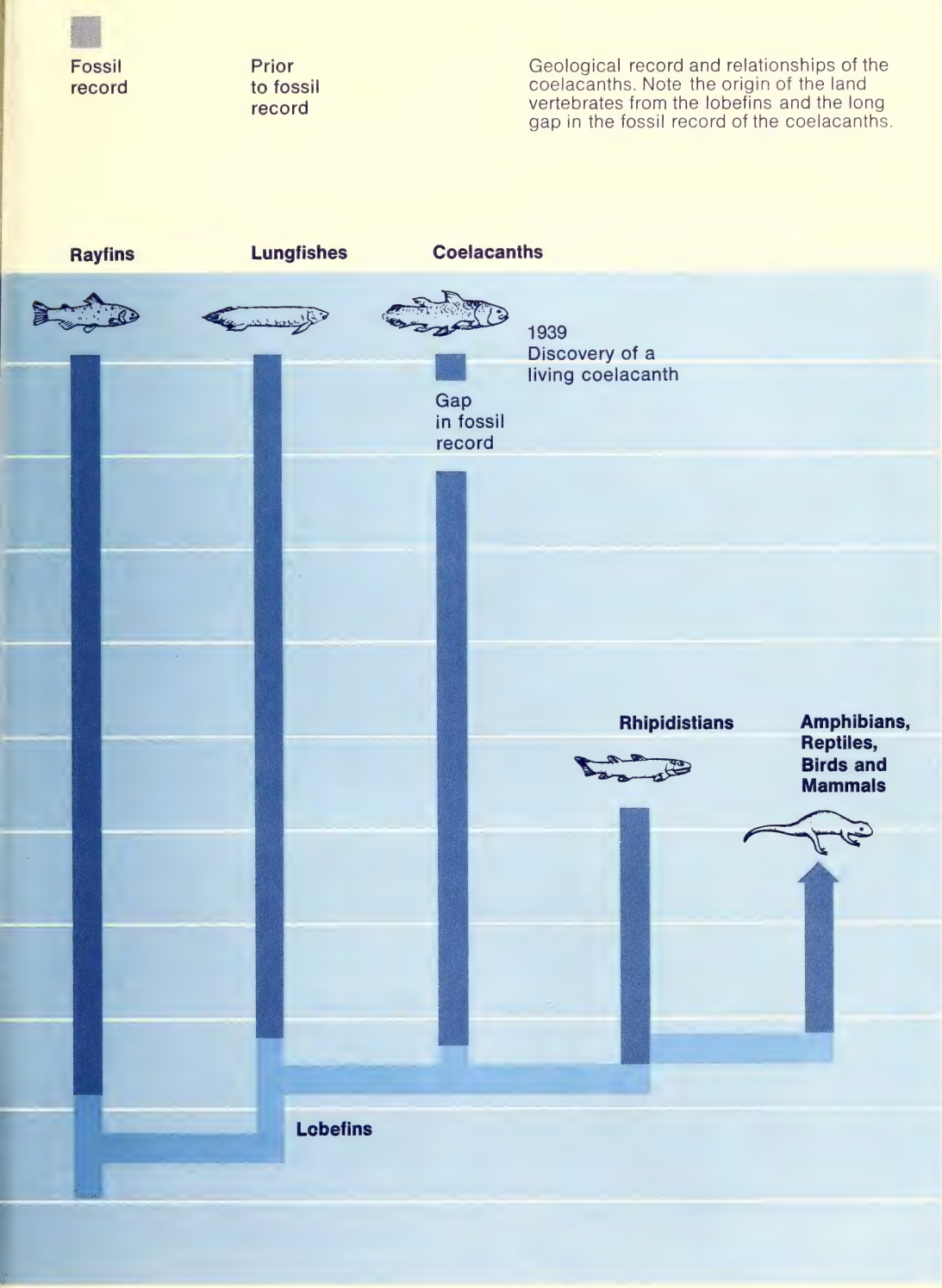
skull, because of its leverage on the lower jaws, throws the lower jaws forward. This may assist in catching prey. In the ancestral forms raising the snout may have been an advantage in taking in air. The brain lies in the posterior part of the skull. The brain is rather small, its weight being less than 3 grams, the length being less than 2½ inches, and its volume filling less than 1 per cent of the cranial cavity in a specimen of 88 pounds (Millot and Anthony 1956).

Body

The body is sturdy, being both thick and deep for its length. Large ovoid scales, which may exceed 1 inch in length, cover the body, becoming smaller posteriorly on the body and on the bases of the fins. The exposed part of the scale is decorated by small ridges or tubercles, giving the body a rasp-like roughness. A lateral line canal, which detects vibrations in the water, runs along the side of the body. Anteriorly the lateral line is high; posteriorly it runs out to the basal tip of the central lobe of the tail fin.

The fins, save for the first dorsal and the caudal fins, bear about 30 rays on thick muscular lobe-like bases. The coelacanth's paired fins in this respect resemble those of the lungfishes and differ from those of the rayfins. It was these muscular lobe-like fin bases in the paired fins of the rhipidistians which gave rise to the limbs of the tetrapod vertebrates. The tail fin too is unusual. Rounded in outline, it bears a small central lobe like a small extra finlet inserted between the upper and lower halves of the main tail fin. This tri-lobed tail is characteristic of the coelacanths and some rhipidistians. The first dorsal

Geological era	Years old (millions)
Cenozoic	64
Cretaceous	136
Jurassic	181
Triassic	230
Permian	280
Pennsylvanian	310
Mississippian	345
Devonian	405
Silurian	425
Ordovician	500



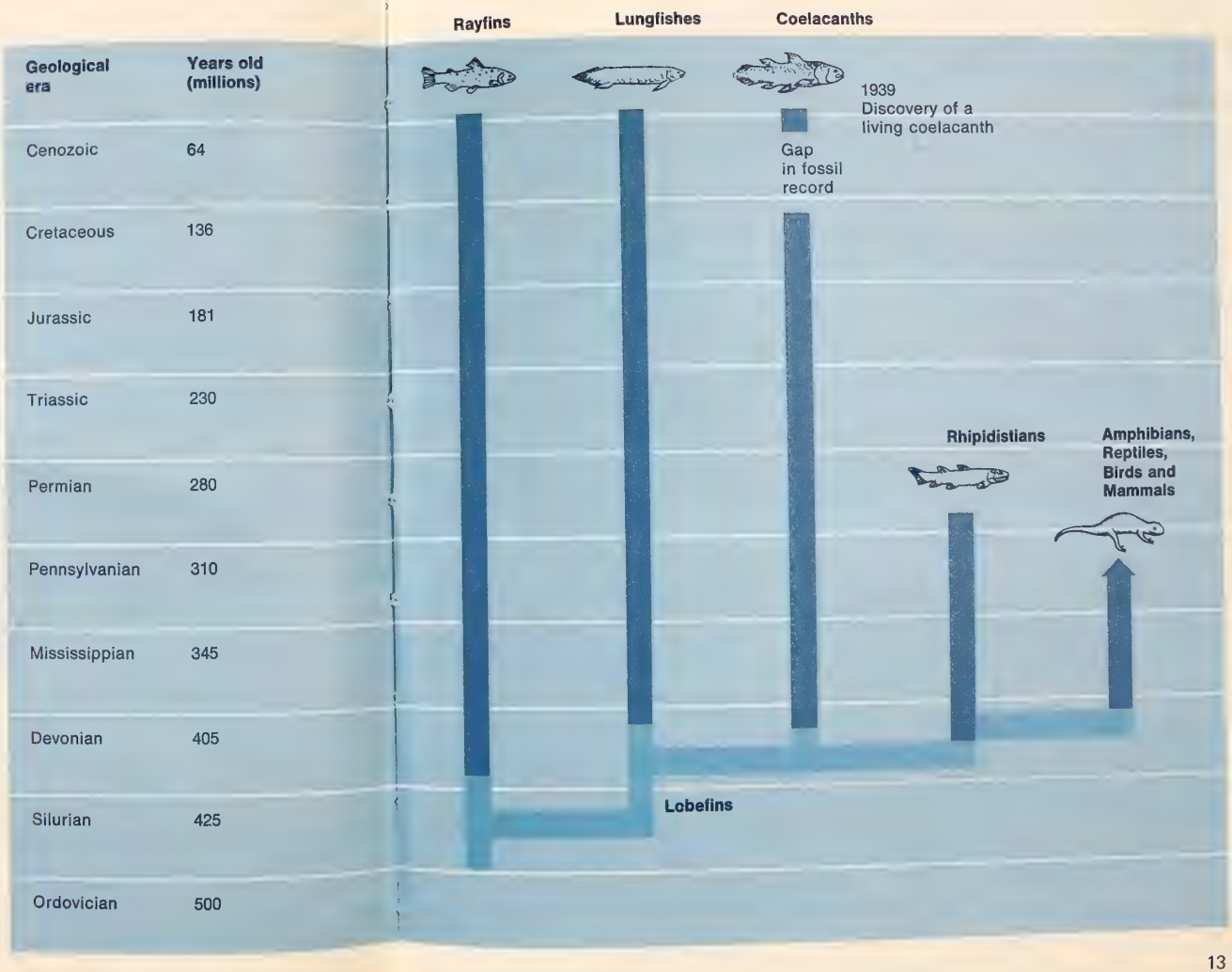
Geological record and relationships of the coelacanths. Note the origin of the land vertebrates from the lobefins and the long gap in the fossil record of the coelacanths.

skull, because of its leverage on the lower jaws, throws the lower jaws forward. This may assist in catching prey. In the ancestral forms raising the snout may have been an advantage in taking in air. The brain lies in the posterior part of the skull. The brain is rather small, its weight being less than 3 grams, the length being less than 2½ inches, and its volume filling less than 1 per cent of the cranial cavity in a specimen of 88 pounds (Millot and Anthony 1956).

Body

The body is sturdy, being both thick and deep for its length. Large ovoid scales, which may exceed 1 inch in length, cover the body, becoming smaller posteriorly on the body and on the bases of the fins. The exposed part of the scale is decorated by small ridges or tubercles, giving the body a rasp-like roughness. A lateral line canal, which detects vibrations in the water, runs along the side of the body. Anteriorly the lateral line is high; posteriorly it runs out to the basal tip of the central lobe of the tail fin.

The fins, save for the first dorsal and the caudal fins, bear about 30 rays on thick muscular lobe-like bases. The coelacanth's paired fins in this respect resemble those of the lungfishes and differ from those of the rayfins. It was these muscular lobe-like fin bases in the paired fins of the rhipidistians which gave rise to the limbs of the tetrapod vertebrates. The tail fin too is unusual. Rounded in outline, it bears a small central lobe like a small extra finlet inserted between the upper and lower halves of the main tail fin. This tri-lobed tail is characteristic of the coelacanths and some rhipidistians. The first dorsal



Geological record and relationships of the coelacanths. Note the origin of the land vertebrates from the lobefins and the long gap in the fossil record of the coelacanths.

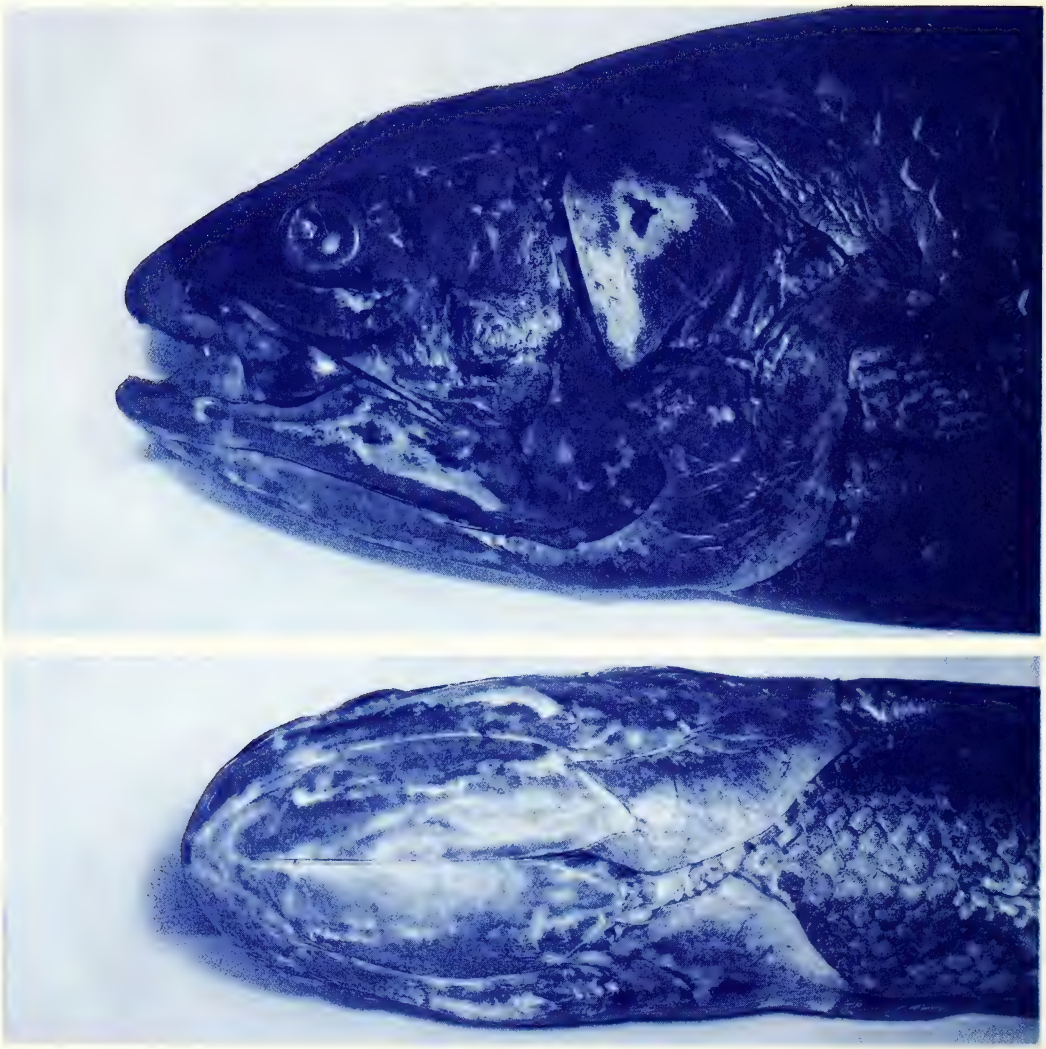


Plate 5. Head, from side and below. The pair of large bony gular plates on the underside of the head are a primitive feature.

fin lacks a lobed base, emerging directly from the body. Its rays are rigid compared with those of the lobed fins. The lobed pectoral fins, those just behind the gill covers, are very mobile, being capable of movement forward or back, up or down.

The backbone of the coelacanth differs from that of more advanced bony fishes. The vertebrae are represented only by small bones above and below the notochord, a flexible rod-like structure that runs from under the hind end of the braincase to the tail. Ribs are completely absent, although present in some fossil coelacanths.

The digestive system is notable for its spiral valve, a coiled structure in the intestine. This presents a considerable area for absorption of nutrients without increasing the length of the intestine. Spiral valves are found only in the more primitive fishes. A rectal gland, an outpocketing of the gut, is found near the end of the intestine. Rectal glands are otherwise known only in the Elasmobranchii where they are believed to secrete excess salt from the body.

In rhipidistians and possibly some coelacanths lungs were present. In *Latimeria* this "lung," lying below the digestive tract, contains no gases, is greatly reduced, and is surrounded by fatty tissue. The organ has evidently degenerated, being no longer functional as a respiratory organ in the deeper well-oxygenated waters of the sea. The other function of the air-filled lung, that of buoyancy, is perhaps replaced through deposition in the "lung" of fat lighter than water. The oil in the skin and flesh may also add to this buoyant effect.

Plate 6. Pectoral fin, showing its mobile, muscular, lobed base.

The blood is unusual in that it contains significant amounts of urea, a nitrogen-containing compound. This condition is otherwise known amongst vertebrates only in the Elasmobranchii, the aestivating African lungfish (*Protopterus aethiopicus*), and the crab-eating frog (*Rana cancrivora*). The urea doubtless helps maintain a water balance in the body. Without the urea water would tend to flow out of the body to the saltier external medium. Probably this feature is an independent development by the marine coelacanths and is not an inheritance from a common ancestor with the elasmobranchs.

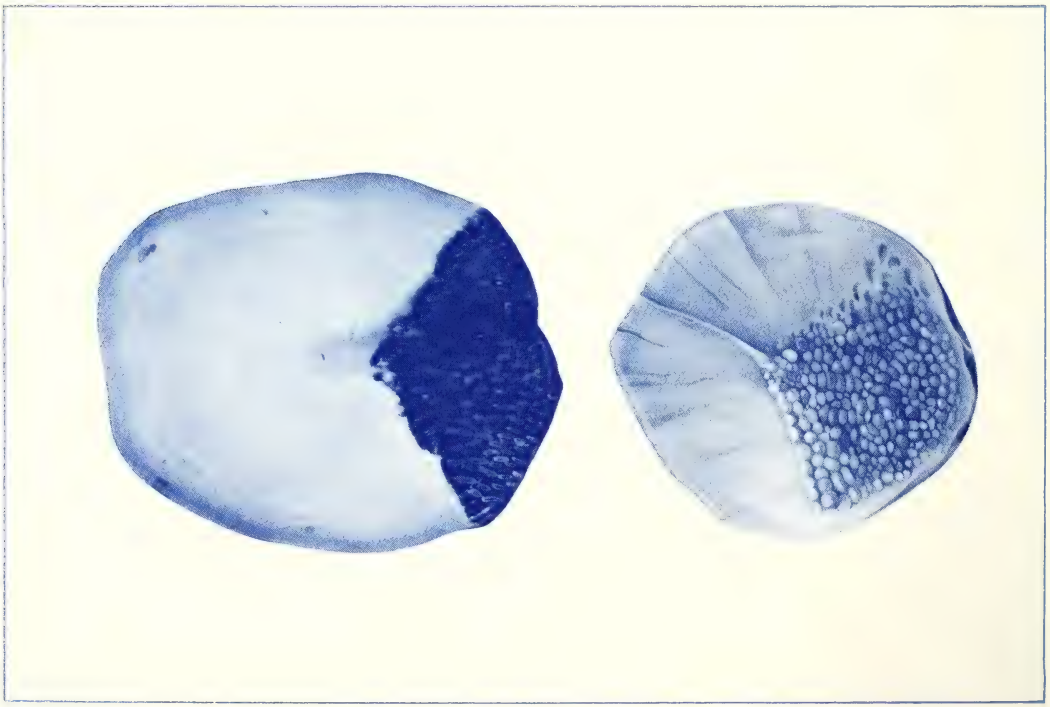


Plate 7. Photograph of a scale of the living *Latimeria* (left) and drawing of a 400-million-year-old Devonian rhipidistian, *Hoploptychius* (right). Note their similarity. Both have tubercules which make them rough. Photo by T. A. Willock, drawing by C. H. Douglas.

Distribution

The first specimen of *Latimeria* was caught off the mouth of the Chalumna River, in southeastern South Africa. That specimen now appears to have been a stray. All subsequent specimens have been caught in the Comores Archipelago, a group of small islands midway between the north end of Madagascar and the central east coast of Africa. In the archipelago, specimens have been taken only in the waters off the islands of Anjouan and Grande Comore.

Most Comoran specimens have been taken in the sea in depths between 260 and 300 metres—that is between 853 and 984 feet—(personal communication Professor Millot). These are waters of moderate depths where some sunlight still penetrates, *not*, as often reported, in the deep sea (i.e. depths of 1,000 metres or about 3,000 feet or more). A few have been taken in shallower waters. The Comoran specimens were taken within one mile of the island shores. Hand fishing from canoes imposes limits on fishing depths and it may be that coelacanths penetrate deeper than this. But, as J. L. B. Smith has pointed out, the structure and coloration of *Latimeria* are not those of a deepsea fish, and it is unlikely that it does penetrate to significantly greater depths.

All specimens have been caught near or on the bottom. Temperatures near the bottom in this area are about 54°F, while at the surface they are about 79°F. The coelacanth inhabits rugged rocky bottom where it is not easily caught by nets.

Food and growth

As attested by its pointed teeth and strong jaws, *Latimeria* is predatory. It feeds on fishes (the lantern fish, *Diaphus metopoclampus*) up to 8 inches in length and on cuttlefish, swallowing them whole. One specimen had a single green leaf in its stomach but this may have been swallowed during its struggles after capture. From an examination of its scales Smith (1940) estimated the age of the first specimen to be between 20 and 25 years.

Reproduction

Much remains to be learned about reproduction in *Latimeria.* However it is now known that *Latimeria* is not a live-bearer, although there is slender evidence suggesting that a certain fossil coelacanth was a live-bearer. Males and females are ripe in the months of December and January. The eggs are large, over 2½ inches, a diameter which exceeds that of any other known bony fish. The eggs are probably shed into the water and fertilized externally (Millot and Anthony 1960).

Fishery

The *gombessa djomole*, as the islanders call it, is caught from small outrigger canoes. Fishing takes place at night using cotton handlines of 250 metres or more in length. To these lines are attached steel leaders and hooks baited with 6-inch pieces of a gempylid fish called *roudi (Promethichthys prometheus).* A 2-pound rock is fastened near the end of the line. The line is lowered to the bottom, then raised up 25 or 30 feet and the rock is released. The line is then fished while the canoe slowly drifts.

Forty-four coelacanths have been caught in the Comores Archipelago from the end of 1952 to mid-1969. One to 8 have been caught per year, with an average of 2.7 a year. In the Comores there are about 300 fishermen fishing in the deeper waters, up to 7 months a year (October to April). This would indicate a low return for a relatively high fishing intensity.

If one assumed that the bait used was moderately attractive and that the normal habitat of *Latimeria* was being fished, one might deduce that the populations were not very large. It would be very regrettable if this species was to become extinct. Perhaps the authorities might consider setting aside an area as a refuge to ensure the preservation of this unique species.

Acknowledgments

The author is most grateful to the following scientists who criticized the manuscript and who added many worthwhile comments: M. Vianey Legendre, Service de la Faune du Québec, Montréal; Dr. D. A. Russell, National Museum of Natural Sciences, Ottawa; Dr. Bobb Schaeffer, American Museum of Natural History, New York; Dr. Margaret Mary Smith, Rhodes University, Grahamstown, South Africa; and Dr. Keith S. Thompson, Yale University, New Haven, Conn. M. R. Martin, Direction de l'Agriculture, de l'Elevage et des Eaux et Forêts, Territoire des Comores, kindly furnished several details on the capture of specimens. It is hardly necessary to add that they are not responsible for the opinions expressed here. The map and drawings are by C. H. Douglas.

Bibliography

The following bibliography of over 120 titles is intended to include only those presenting significant new information or new interpretations, or having some other special significance. Thus many textbooks or works of popular nature mentioning *Latimeria chalumnae* only casually are omitted. Books or articles which would be of interest to the layman are marked by an asterisk.

Anderson, I. G. and G. A. D. Haslewood

(1964). Comparative studies of "bile salts" 20. Bile salts of the coelacanth, *Latimeria chalumnae* Smith. *Biochemical Journal* (Cambridge) 93(1): 34-9, illus.

Anonymous

(1969). Lobe finned fishes. *Nature* (London) 221 (5183): 803-4.

Anthony, Jean, Jacques Millot and Daniel Robineau

(1965). Le coeur et l'aorte ventrale de *Latimeria chalumnae* (poisson coelacanthidé). *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences* (Paris) 261: 223-26, 1 pl., 1 fig.

Anthony, Jean and Daniel Robineau

(1968). Branchies et artères branchiales de *Latimeria chalumnae* (poisson coelacanthidé). *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences* (Paris) 226(4): 375-78, illus.

Arnould-Saget, S.

(1954). La place du coelacanthe dans l'histoire des poissons. *Bulletin de la Société de Science Naturelle de Tunisie* 6: 83-9.

Ax, P.

(1960). *Die Entdeckung neuer Organisationstypen im Tierreich.* Wittenberg Luther-stadt (A. Ziemsem Verlag). 116 p., illus.

Berg, Leo Semenovitch

(1940). Classification of fishes both recent and fossil. *Trudi Zoologicheskogo Instituta, Akademiya Nauk SSSR* 5: 1-517, 190 figs. (Russian and English).

Bernhauser, A.

(1961). Zur Knocken und Zahnhistorie von *Latimeria chalumnae* Smith und einiger Fossilformen. *Wissenschaften* (Wien) I 170: 119-37, 12 figs.

Bock, Wilhelm

*(1952). Secrets of the coelacanths. *Frontiers* (Philadelphia) 17: 99-102, 3 figs.

Bolivary Pieltain, C.

(1959). Los celacantos estudiados como animales actuales aportación valiosa a su conocimiento. *Geos* (Caracas) 2: 32-4.

Brown, G. W., Jr. and S. G. Brown

(1966). Intermediary nitrogen metabolism of the coelacanth, *Latimeria chalumnae. American Zoologist* 6(4): 577.

(1967). Urea and its formation in coelacanth liver. *Science* (New York) 155(3762): 570-73, illus.

Cowgill, Ursula M., G. E. Hutchinson and H. Catherine W. Skinner

(1968). The elementary composition of *Latimeria chalumnae* Smith. *Proceedings of the Academy of Natural Sciences* 60(2): 456-63, illus.

Due Rojo, A.

(1957). Notas paleontologicas III. Fósiles vivos. *Notas Instuto Geol. Español* 47: 107-27.

Du Toit, C. A.

(1953). *See* Toit, C. A. du

Fox, D. I. and G. F. Crossier

(1965). Absence or singular specificity of carotenoids in some lower fishes. *Science* (New York) 150(3697): 771-73.

François, Y.

(1959). La nageoire dorsale, anatomie comparée et évolution. *Année biologique* (Paris) (3)35: 81-113, 18 figs.

Grant, F. Blake and G. E. Pickford

(1966). Ionic composition of urea and serum osmolality in the blood of the coelacanth *Latimeria chalumnae. American Zoologist* 6(4): 545-46.

Hargis, W. J., Jr.

(1958). Coelacanths and monogeneids. *Journal of Parasitology* 44(2): 191. (Issued also as *Contributions of Virginia Fisheries Laboratory,* (78) 1958-59, pub. 1960.)

Ihle, J. E. W. and M. E. Ihle-Landenberg

(1948). Niew onderzoekingen over *Latimeria chalumnae. Vakbl. Biol. Helder* 28(4): 65-71, 5 text-figs.

Jarvik, Erick

(1960). Les crossoptérygiens et l'origine des tétrapodes. p. 37-40, figs. 11-28. *In: Théories de l'évolution des vertébrés reconsidérées à la lumière des récentes découvertes sur les vertébrés inférieurs.* Masson et Cie, Paris. 104 p., 30 figs.

Lehman, Jean-Pierre

(1959). Actinistia. p. 99-101, fig. 44. *In: L'évolution des vertébrés inférieurs.* Dunod, Paris. Monographies Dunod. 188 p., 94 figs.

(1966). Crossopterygii. p. 301-412, figs 1-88. *In:* Jean Piveteau, éd. *Traité de Paléontologie.* Vol. 3 of Tome IV, Actinoptérigiens, Crossoptérigiens, Dipneustes. Masson et Cie, Paris. 442 p., 11 pls., 357 text-figs.

Lenoble, J. and Y. Le Grand

(1954). Le tapis de l'oeil du Coelacanthe *(Latimeria anjouanae)* [Smith]. *Bulletin Musée d'Histoire naturelle* (Paris) (2)26: 460-63, 3 figs.

Mathews, M. B.

(1966). The molecular evolution of cartilage. *Clinical Orthopaedics* 48: 267-83.

McAllister, D. E.

(1968). The evolution of branchiostegals and the classification of teleostome fishes, living and fossil. *Bulletin of the National Museum of Canada* (221): 1-239, 21 pls., 3 text-figs.

Menaché, M.

(1955). Étude hydrologique sommaire de la région d'Anjouan en rapport avec la pêche de trois coelacanthes. *Mémoires de l'Institut scientifique de Madagascar, Série A* (Tananarive) 9: 151-85.

Merle, R.

(1953). Le coelacanthidé d'Anjouan. *La Nature* (Paris) 1953: 95-6.

Millot, Jacques

*(1953). "Notre" Coelacanthe. *La Revue de Madagascar* (17): 18-20.

(1954*a*). Les nouveaux coelacanthes. *La Nature* (Paris) (3228): 121-23, 4 figs.

(1954*b*). Le coelacanthe, poisson fossile vivant. *Science et Nature* (2): 13-15, 5 photos.

(1954*c*). Le troisième coelacanthe. *Le Naturaliste Malgache*, Supplément 1, 22 p., 50 pls.

(1954*d*). Further study of the coelacanth — Remains of the pulmonary organ. *The Times* (London) June 3, 7(52): 948.

(1954*e*). New facts about coelacanths. *Nature* (London) 174(4427): 426-27, 1 fig.

(1955*a*). Unité spécifique des coelacanthes actuels. *La Nature* (Paris) (3238): 58-9, 2 figs.

(1955*b*). The coelacanth. *Scientific American* 193 (6): 34-9, illus.

(1955*c*). La première femelle adulte de coelanthe. *La Nature* (Paris) (3241): 203.

(1955*d*). First observations on a living coelacanth. *Nature* (London) 175 (4452): 362-63.

(1955*e*). À propos des coelacanthes. *La Nature* (Paris) (3241): 202-03, 1 fig.

(1964). Le diencéphale de *Latimeria chalumnae* Smith (poisson coelacanthidé). *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences* (Paris) 258: 5051-55, 2 figs.

Millot, Jacques and Jean Anthony

(1954). Tubes rostraux et tubes nasaux de *Latimeria* (Coelacanthidae). *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences* (Paris) 239: 1241-43, 1 fig.

(1955*a*). Les canaux sensoriels de la tête chez *Latimeria* (Coelacanthidae). *Compte Rendu VI^e Congrès international d'Anatomie.* Masson et C^ie, Paris p. 161-62.

(1955*b*). Considérations physiomorphologiques sur la tête de *Latimeria* (Crossoptérygien coelacanthidé). *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences* (Paris) 241: 114-16.

(1955*c*). L'articulation intracrânienne de *Latimeria chalumnae* (Coelacanthidae). *Compte Rendu VI^e Congrès international d'Anatomie.* Masson et C^ie, Paris. p. 161-62.

(1956*a*). Note préliminaire sur le thymus et la glande thyroide de *Latimeria chalumnae* (Crossoptérygien coelacanthidé). *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences* (Paris) 242: 560-62.

(1956*b*). L'organe rostral de *Latimeria* (Crossoptérygien coelacanthidé). *Annales des Sciences Naturelles.* Zoologie (Paris) 11^e série. 18: 381-89, 7 pls.

(1956*c*). Considérations préliminaires sur le squelette axial et le système nerveux central de *Latimeria chalumnae* Smith. *Mémoires de l'Institut scientifique de Madagascar. Série A.* Biologie Animale. (Tananarive) 11: 167-88, 14 pls. (one plate in colour).

(1958*a*). Latimeria chalumnae, dernier des crossoptérygiens. *In*: *Traité de Zoologie.* P. Grassé, ed. (Paris) 13: 2553-97, text-figs. 1831-56 (one plate in colour).

(1958*b*). *Anatomie de Latimeria chalumnae.* Tome 1, Squelette, muscles et formations de soutien. Editions du Centre National de la Recherche Scientifique, Paris. 122 p., 30 text-figs., 80 pls.

(1958*c*). De l'existence chez *Latimeria chalumnae* Smith (Coelacanthidae) d'un organe régulateur du courant sanguin suprabranchial. *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences* (Paris) 246: 1600-02, 1 fig.

(1959*a*). Les neuromastes du système latéral de *Latimeria chalumnae. Annales des Sciences Naturelles. Zoologie* (Paris) Série 12, 1: 317-28, 7 figs.

(1959*b*). Résultats actuels de l'étude du coelacanthe, *Latimeria chalumnae* Smith, dernier des crossoptérygiens. *Proceedings of the International Congress of Zoology* (London) 15: 36-44.

(1960*a*). Le cloaque chez les coelacanthes. *Bulletin Musée d'Histoire Naturelle* (Paris) (2) 32: 287-89, 1 pl., 2 figs.

(1960*b*). Le plus vieux poisson du monde — état actuel de nos connaissances sur le coelacanthe (*Latimeria chalumnae* Smith). *Sciences* (Paris) (6): 7-20, 6 figs.

(1960*c*). Appareil génital et reproduction des coelacanthes. *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences* (Paris) 254: 2067-68, 6 figs.

(1962). Premières précisions sur l'organisation du télencéphale chez *Latimeria chalumnae* (poisson crossoptérygien coelacanthidé). *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences* (Paris) 254: 2067-68, 6 figs.

(1965). *Anatomie de Latimeria chalumnae.* Tome II, Système nerveux et organes des sens. Editions du Centre National de la Recherche Scientifique, Paris. 131 p., 56 text-figs., 76 pls.

(1967). L'organisation générale du prosencéphale de *Latimeria chalumnae* Smith (poisson crossoptérygien coelacanthidé). p. 40-60, illus. *In: Symposium on phylogenesis and ontogenesis of the forebrain.* 15-19 August, 1965. Frankfurt and Sprendlingen. Plenum Press, New York.

Millot, Jacques and N. Carasso

(1955). Note préliminaire sur l'oeil de *Latimeria* (Coelacanthidae). *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences* (Paris) 241: 576-77.

Millot, Jacques, Rudolf Nieuwenhuys and Jean Anthony

(1964). La diencéphale de *Latimeria chalumnae* Smith (poisson coelacanthidé). *Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences* (Paris) 258: 5051-55.

Millot, Jacques and A. Policard

(1955). Sur la structure inframicroscopique du tissu conjonctif du coelacanthe. *Bulletin de Microscopie Appliquée* (Paris) 5(7/8): 94-5, 1 pl., 2 figs.

Monod, Th.

(1955). Sur une larve de Gnathiidae (*Praniza milloti*, nov. sp.), parasite de *Latimeria chalumnae* (Coelacanthe). *Mémoires de l'Institut scientifique de Madagascar, Série A,* Biologie Animale. (Tananarive) 9: 91-4.

Munk, O.

(1964). The eye of *Calamoichthys calabaricus* Smith, 1865 (Polypteridae Pisces) compared with the eye of other fishes. *Videnskabelige Meddelelser Fra Dansk Naturhistorisk Forening* 127: 113-25.

Nelson, Gareth J.

(1968). Gill-arch structure in *Acanthodes.* Current problems of lower vertebrate phylogeny. *Nobel Symposium 4:* p. 129-43, 6 figs. Almqvist & Wiksell, Stockholm. Interscience Publishers, New York, London, Sydney.

(1969). Gill-arches and the phylogeny of fishes with notes on the classification of vertebrates. *Bulletin of the American Museum of Natural History* 141: 475-552, pls. 79-92, 26 text-figs.

(1970). Subcephalic muscles and intracranial joints of sarcopterygian and other fishes. *Copeia* for 1970 (3): 468-471, 1 fig.

Nevenzel, Judd C., W. Rodegker, J. F. Mead and M. S. Gordon
(1966). Lipids of the living coelacanth, *Latimeria chalumnae. Science* (Washington) 152: (3730): 1753-55.

Nieuwenhuys, Rudolf

(1965). The forebrain of the crossopterygian *Latimeria chalumnae* Smith. *Journal of Morphology* 117(1): 1-24, 7 pls., 1 fig.

O[lofsson], O.

(1953). Nytt fynd av "fossil" fisk vid Madagascar. *Svensk Fiskeri Tidskrift* (Lund) 62: 14-15, 2 figs.

Peheta, V. P.

(1968). [*Enchondral ossification in Latimeria chalumnae Smith.*] *Dopov Academii Nauk UKR RSR* 30(7): 653-56, illus. (In Russian, English summary).

Pickford, Grace E. and F. Blake Grant

(1967). Serum osmolality in the coelacanth, *Latimeria chalumnae:* urea retention and ion regulation. *Science* 155(3762): 568-70.

Prailaune, S.

(1955). Sur l'hémoglobine du coelacanthe. *Compte Rendu Hebdomadaire des Séances de la Société de Biologie* (Paris) 149: 655-57.

Romer, Alfred Sherwood

(1955). *Vertebrate paleontology.* 2nd ed. University of Chicago Press, 687 p., 377 figs.

(1967). *Vertebrate paleontology.* 3rd ed. University of Chicago Press, 468 p., illus.

Roux, G. H.

(1942). The microscopic anatomy of the *Latimeria* scale. *South African Journal of Medical Science*, Biological Supplement 7: 1-18, 1 pl., 9 text-figs.

(1953). *Latimeria* and the history of coelacanth fishes. *Transactions of the New York Academy of Science*, Series II, 15(6): 170-78, illus.

(1958). Review of: Anatomie de *Latimeria chalumnae. Science* (Washington) 129: 1124-25.

(1959). A study of *Latimeria chalumnae. Natural History* (New York) 68(8): 426-29.

Sacchi, Vialli G.

(1965). Immagini di vita nei fossili. *Atti dell' Instituto Geologico, Università di Pavia* 16: 72-80, 2 pls.

Schaeffer, Bobb

(1948). A study of *Diplurus longicaudatus* with notes on the body form and locomotion of the Coelacanthini. *American Museum Novitates* (1378): 32 p., 5 figs.

(1952*a*). Rates of evolution in coelacanth and dipnoan fishes. *Evolution* 6: 101-11, 3 figs.

(1952*b*). The Triassic coelacanth fish *Diplurus*, with observations on the evolution of the Coelacanthi. *Bulletin of the American Museum of Natural History* 99: 25-78, 16 text-figs, pls. 5-16.

(1967). Osteichthyan vertebrae. *Journal of the Linnean Society of London* (Zoology) 47(311): 185-95, 1 pl., 3 text-figs.

Schindler, O.

(1955). Neues von den lebenden "Urwelt-fischen". *Kosmas* (Stuttgart) 51: 581-88, 11 figs.

Smith, J. L. B.

(1939*a*). A living fish of Mesozoic type. *Nature* (London) 143. 455-56, 1 fig.

(1939*b*). The living coelacanthid fish from South Africa. *Nature* (London) 143: 748-50, 2 figs.

(1939*c*). A surviving fish of the order Actinistia. Preliminary announcement to the society. *Transactions of the Royal Society of South Africa* 27: 47-50, pls. 3-7.

(1940). A living coelacanth fish from South Africa. *Transactions of the Royal Society of South Africa* 28: 1-106, pls. 1-44.

(1950). *The sea fishes of South Africa.* 2nd ed. Central News Agency, 550 p., 1100 figs., 102 pls. (*Latimeria chalumnae* p. 79-80, fig. 98, col. pl. 66).

(1953*a*). Wie ich den Urwelt-Fisch fand. *Orion* (München), April.

(1953*b*). The two coelacanths. *Bulletin of the South African Museum Association* 5: 206-10.

(1953*c*). The second coelacanth. *Nature* (London) 171: 99-102.

(1953*d*). Problems of the coelacanth. *South African Journal of Science* 49: 279-81.

(1955). Live coelacanths. *Nature* (London) 176: 473.

*(1956). *Old fourlegs, the story of the coelacanth.* Longmans, Green and Co., London, New York, Toronto. 260 p., illus. (1957 edition by Readers Union, 1958 by Pan.)

Other editions are as follows:

*(1956). *The search beneath the sea.* Henry Holt, New York, 274 p., illus.

*(1957). *Vergangenheit steigt aus den meer.* Günther Verlag, Stuttgart.

*(1960). *À la poursuite de coelacanthe.* Plon, Paris.

*(1962). *Starina tchetveronog.* State Publisher of Geographical Literature, Moscow.

*(1965). *Ou Vierpool.* Tafelberg-vitgewers, Capetown.

(1969). *Cesta za stvornozcom.* Dilia, Prague.

Smith, J. L. B. and Mary Margaret Smith

(1963). *The fishes of Seychelles.* Department of Ichthyology, Rhodes University, Grahamstown. 215 p., 98 pl., 2 text-figs.

Smith, Mary Margaret

(1970). The search for the world's oldest fish. *Oceans* 3(6): 26-36, 6 photos (1 in colour), 1 drawing.

Stensio, Erik A.

(1947). The sensory lines and dermal bones of the cheek in fishes and amphibians. *Kungliga Svenska Vetenskapsekademiens Handlingar*, 3rd series, 24(3): 195 p., 38 figs.

Svetovidov, A. N.

(1956). [*First observations on a "living fossil".*] *Priroda* 5: 104-05. (In Russian)

Talbot, F. H.

(1966). The coelacanth, living relict of 50 million years ago. *Australian Natural History* 15(5): 137-40.

Thomson, Keith Stewart

(1966*a*). Mobility of the skull and fins in the coelacanth (*Latimeria chalumnae* Smith). *American Zoologist* 6(4): 565-66.

*(1966*b*). The history of the coelacanth. *Discovery* 2(1): 27-32, illus.

(1966*c*). Intracranial mobility in the coelacanth. *Science* 153 (3739): 999-1000, 1 fig.

(1967). Mechanisms of intracranial kinetics in fossil rhipidistian fishes (Crossopterygii) and their relatives. *Journal of the Linnean Society* (Zoology) 46: 223-53, 17 figs.

(1969). The biology of the lobe-finned fishes. *Biological Reviews* 44: 91-154, 11 figs.

Toit, C. A. du

(1953). Some problems on the coelacanth restated. *South African Journal of Science* 49: 332-33.

Trewavas, Ethylwynn

(1958). The coelacanth yields its secrets. *Discovery* (Norwich) 19: 196-205, 8 figs.

Tuzet, O. and Jacques Millot

(1959). La spermatogenèse de *Latimeria chalumnae* Smith (Crossoptérygien coelacanthidé). *Annales des Sciences Naturelles, Zoologie* (Paris) 12e série, 1: 61-9, 2 pls., 3 figs.

Vialli, M.

(1957). La quantitá di acido dessossiribonucleia per nucleo negli entroati'di Latimeria. *Rendiconti dell'Instituto Lombardo, Classe di Scienze Fisiche, Matematiche e Naturali* (Milano) 91: 680-86.

Vorobeva, E. I. and D. V. Obruchev

(1964). ["Subclass Sarcopterygii".] p. 268-322, 5 pls., text-figs 1-67. *In: Osnovi paleontologii*, D. V. Obruchev, ed., Nauka Moskva. 522 p. (In Russian)

Wahlert, Gerd von

(1968*a*). Demonstration von *Latimeria chalumnae* J. L. B. Smith. *Verhandlungen der Deutschen Zoologischen Gesellschaft* (Heidelberg) 1967.

(1968*b*). Das "Dritte Flosenpaar" von Latimeria. *Stuttgarter Beitrage Naturkunde.*

(1968*c*). *Latimeria* und die Geschichte der Wirbeltiere. Eine evolutionsbiologie Untersuchung. *Fortschritte der evolutionsforschung.* Band IV, 125 p., 63 figs. Gustav Fischer Verlag, Stuttgart.

Wahlert, Gerd von and H. von Wahlert

(1967). Bau und Funktion der paddelförmigen Unpaarflossen von *Latimeria chalumnae* J. L. B. Smith. *Stuttgarter Beitrage Naturkunde* 172.

Watson, David Meredith Seares

*(1954). Coelacanths. *New Biology* (London) (16): 86-92, illus.

(1955). Coelacanths. *Proceedings of the Royal Institution of Great Britain* (London) 35: 782-86, 2 figs.

White, Errol Ivor

(1939). One of the most amazing events in the realm of natural history in the twentieth century: The discovery of a living fish of the coelacanth group, thought to have been extinct 50 million years, off South Africa. *Illustrated London News* 194: 380.

(1939*b*). A living fossil. *Listener* (London) 21: 663-64.

*(1953). The coelacanth fish. *Discovery* (Norwich) 14: 113-17, 6 figs.

(1954*a*). The coelacanth fishes. *Annual Report of the Smithsonian Institution* (Washington) 1953: 351-60, 1 pl.

*(1954*b*). More about the coelacanths. *Discovery* (Norwich) 15(8): 332-35, 8 figs.

Willis, J. H.

(1953). The second coelacanth. *Victorian Naturalist* (Melbourne) 70: 43, 1 fig.

Woodward, Arthur Smith

(1940). The surviving crossopterygian fish, *Latimeria. Nature* (London) 146 (3689): 53-4.

Zorarinsson, S.

(1953). "Utdaudir" fiskari fullu fjöri. *Náttúrufraedingurinn* 23: 93-5, 2 figs.

Notes

Notes

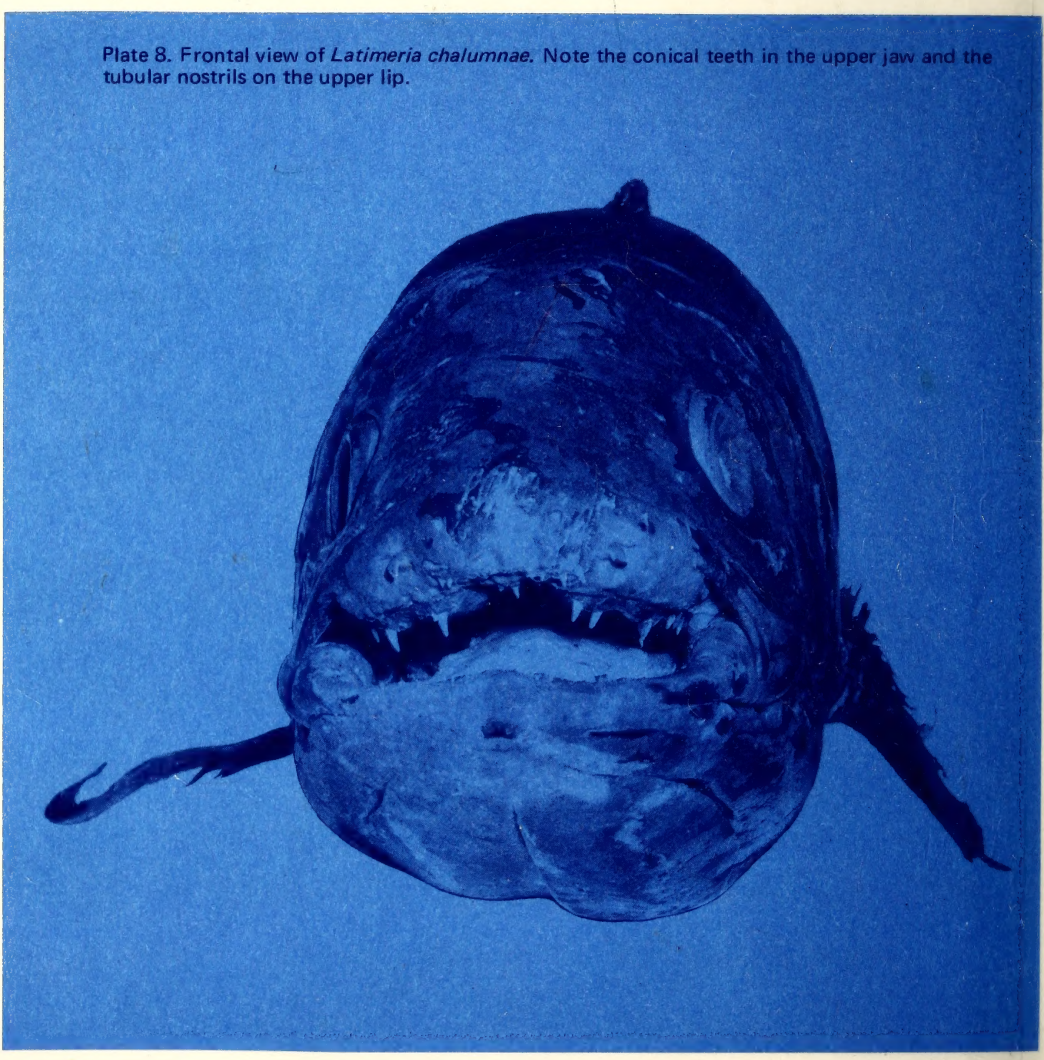
Notes

*4312-9
5-15
S

PERMA-BOUND®
PAT. NO. 3,161,423

© Crown Copyrights reserved

Plate 8. Frontal view of *Latimeria chalumnae*. Note the conical teeth in the upper jaw and the tubular nostrils on the upper lip.



National Museums of Canada
Ottawa, Canada
1971

P 0 9 8 7 6 5 4 3 2
Y 7 9 8 7 6 5 4 3 2
Litho in Canada